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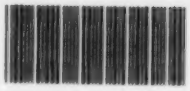

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NAV-ICE/MARINE-VUE INTEGRATION

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Final Report

by

R.T. Lowry
J.G. McAvoy
INTERA Technologies Ltd.
2500-101 6th Ave S.W.
CALGARY T2P 3P4
Ph.(403) 266-0900
Fax (403) 265 0499

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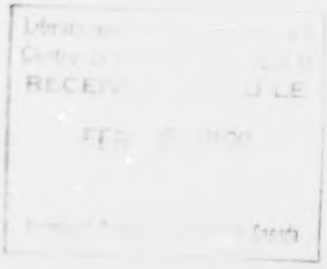

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Un sommaire en français de ce rapport est inclus avant la table des matières.

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16. Abstract

Recent developments in ship-borne radar workstations at INTERA Technologies have centred on the support of the MV Arctic and the development, with TDC, Canarctic and CCIW of systems for the display and analysis of both Airborne SAR and the ships Marine Radar data. Previous work had shown the need for a new type of Marine display that had three key additional features:

1. The ability to view the image side by side, in daylight, with the airborne SAR data;
2. The ability to freeze the display, with no fading of the image; and
3. The ability to communicate data (image and control) from the marine display to the SAR display.

It was the purpose of the work described in this report to overcome those shortcomings, and to complete the integration of the Marine Radar into the SAR for tactical ice navigation. The TDC Folsom Scan converter was modified, and additional control, data processing, and display hardware were designed and fabricated. The modified scan converter system was integrated with STAR-VUE, the airborne radar display system on the MV Arctic, and was installed for the final voyage of the MV Arctic in November of 1988.

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16. Resumé

Les recherches récentes sur le système de visualisation radar intégré menées par INTERA Technologies Ltd. ont porté sur le N. M. Arctic comme support du système et sur la mise au point (avec le concours du CDT, de Canarctic et de CCIW) de sous-systèmes d'affichage et d'analyse de l'information fournie par le radar à antenne synthétique aéroporté et par le radar de bord. Les recherches antérieures avaient montré qu'il était nécessaire de disposer, pour le radar de bord, d'une visualisation possédant les trois fonctions supplémentaires suivantes:

1. Aptitude à afficher l'imagerie radar de bord juxtaposée à celle du radar aéroporté;
2. Aptitude à figer l'image sans évanouissement de celle-ci;
3. Aptitude à transférer des données (imagerie, commandes) de l'écran de navigation maritime à l'écran du radar aéroporté.

La recherche décrite dans le présent rapport a eu pour objet de surmonter ces difficultés et de mener à bien les travaux d'intégration des imageries radar de bord et radar aéroporté dans un système de navigation maritime dans les glaces. Pour cela, le convertisseur de balayage Folsom a dû être modifié et il a fallu concevoir et réaliser des composants pour les commandes, le traitement des données et l'affichage. Ce système a ensuite été intégré au système STAR-VUE d'affichage de l'imagerie du radar aéroporté et le tout installé à bord du N. M. Arctic en vue de son périple final dans l'Arctique en novembre 1988.

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SUMMARY

INTERA Technologies has been developing ship-borne radar workstations for a number of years, both for stationary drill ship applications and for transiting ice breakers. Recent developments have centred on the support of the MV Arctic and the development (with TDC, Canarctic and CCIW) of systems for the display and analysis of both Airborne SAR and the ships Marine Radar data. Previous work had shown the need for a new type of Marine display that had three key features in addition to those found on a normal analogue ships PPI display. These were:

1- The ability to view the image side by side, under normal lighting conditions, with the airborne SAR data;

2- The ability to freeze the display, with no fading of the image; and

3- The ability to communicate data (image and control) from the marine display to the SAR display.

Previous studies had shown that the use of a digital scan converter to convert marine radar to a raster scan image, for display on a TV style monitor, would meet the first two criteria. However, then available displays lacked the normal Marine Radar controls, and were found to be extremely hard to use by the ship's crew. It was the purpose of the work described in this report to overcome those shortcomings, and to complete the integration of the Marine Radar into the SAR for tactical ice navigation.

The method chosen was to use the existing Folsom scan converter, modify the internal software and hardware, and build the needed user interface software/hardware based on a microprocessor. The Folsom unit has the needed GPIB (IEEE 488), RS232 computer interfaces and RS170 Video interfaces, as well as an appropriate forward filling scan conversion scheme to make it an appropriate basis for the development.

Three new hardware components were added to the system to make up what is now called MARINE-VUE. These were:

1- The MARINE-VUE Control Panel (MVCP)
This sits in front of the user, and contains the needed controls for the video display (scale, origin, gain etc.) , the use of the cursor, and the control of the Scan Converter.

2-The Video Processor (VP)
This rack mounted unit pre-processes the analogue Video before it reaches the Scan Converter, where it is digitized. The VP is controlled from the MVCP, and contains the video gain stages, the STC and FTC circuits, as well as all appropriate buffering.

3- The Dual Channel Video Mixer (DCVM)
This is used in conjunction with the dual polarized radar (HH polarised transmit, H and V polarised receive) to combine the two video channels to be fed into one Scan Converter. It is rack mounted with only front panel controls.

The modified scan converter system was integrated with STAR-VUE, the airborne radar display system on the MV Arctic, and installed for the final voyage of the MV Arctic in November of 1988.

SOMMAIRE

INTERA Technologies Ltd. s'intéresse depuis plusieurs années à un système de visualisation radar intégré utilisable tant par les navires de forage que par les cargos brise-glace. La recherche s'est depuis peu concentrée sur le N. M. Arctic comme support du système et sur la mise au point (avec le concours de CDT, du Canarctic et de CCIW), de sous-systèmes d'affichage et d'analyse de l'information fournie par le radar à antenne synthétique aéroporté et par le radar de bord. Les recherches antérieures avaient montré qu'il était nécessaire de disposer, pour le radar de bord d'une visualisation possédant trois fonctions supplémentaires que ne possède normalement pas le radar panoramique analogique (PPI) de caractéristiques comparables, à savoir:

1. Aptitude à afficher l'imagerie radar de bord juxtaposée à celle du radar aéroporté;

2. Aptitude à figer l'image sans évanouissement de celle-ci;

3. Aptitude à transférer des données (imagerie, commandes) de l'écran de navigation maritime à l'écran du radar aéroporté.

Des études antérieures avaient montré que par l'utilisation d'un convertisseur de balayage servant à convertir l'imagerie radar en une version affichable sur écran de télévision, on pourrait réaliser une visualisation ayant les deux premiers attributs précités. Mais les écrans de visualisation disponibles à l'époque n'avaient pas toutes les commandes dont est normalement équipé un radar de bord et, de plus, le personnel navigateur éprouvait de la difficulté à les utiliser. La recherche décrite dans le présent rapport a eu pour objet de surmonter ces difficultés et de mener à bien les travaux d'intégration des imageries radar de bord et radar aéroporté dans un système de navigation maritime dans les glaces.

Les chercheurs se sont servis, pour cela du convertisseur de balayage Folson existant, dont ils ont modifié la structure logicielle et matérielle, et ont réalisé une interface homme-système pilotée par un microprocesseur. Le convertisseur Folsom comporte un bus d'interface d'usage général (GPIB) conforme à la norme IEEE 488, des interfaces informatiques RS232 et des interfaces vidéo RS170, en plus d'exploiter une technique appropriée de conversion de balayage à remplissage aval susceptible de faciliter le développement ultérieur du système.

Le système baptisé MARINE-VUE ainsi perfectionné comporte les trois sous-systèmes suivants:

1. Le panneau de commande MARINE-VUE (PCMV), devant lequel l'utilisateur est assis et qui renferme les commandes d'affichage vidéo nécessaires: échelle, origine, gain, etc., le curseur et les commandes du convertisseur de balayage.

2. Le processeur vidéo radar, monté sur bâti, qui soumet les signaux analogiques à un certain nombre de traitements avant de les transmettre au convertisseur de balayage qui les numérise. Le processeur, commandé à partir du PCMV, renferme les circuits de gain vidéo, de STC (gain variable avec le temps), de FTC (découpage des échos longs) et de mémoire tampon.

3. Le mélangeur vidéo à deux voies, lié au radar à polarisation double (polarisation H et H à l'émission et H et V à la réception). Il sert à mélanger les signaux de deux voies vidéo avant de les transmettre sous forme de signal combiné au convertisseur de balayage. Monté sur bâti, il dispose d'une platine frontale pour les commandes.

Le système MARINE-VUE, ainsi modifié a été intégré au système STAR-VUE d'affichage de l'imagerie du radar aéroporté et le tout installé à bord du N.M. Arctic en vue de son périple final dans l'Arctique en novembre 1988.

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1. INTRODUCTION

INTERA Technologies along with Canarctic Shipping and DFO have been developing the use of marine radar for displaying ice with the purpose of improving navigation in Arctic waters. It has been the long term objective of INTERA and Canarctic Shipping to integrate marine radar data with the SAR data available from INTERA's STAR-1 equipped aircraft. By comparing real-time marine radar images with valid SAR imagery it is possible to navigate ice infested waters with increased economy and safety. Existing methods require dedicated attention, particularly in ice that is fragmented or dynamic. This project has concentrated on developing the hardware and software necessary to enable marine radar and SAR images to be readily brought to the same scale and orientation and allow radar fix data to be displayed on the same screen as the SAR imagery. Successful implementation of these functions is necessary to establish an integrated Arctic navigation system that may be used directly by the Navigating Officer rather than a dedicated expert.

Other developments conducted within this program are to provide a method of logging SAR and marine radar parts and hardware changes to support future experiments with cross polarized radars.

1.1 Navigation in ice using SAR imagery and marine radar

SAR imagery reveals detailed information on the nature of ice in Arctic waters. Not only does it indicate the ice edge but tone indicates ice age and other factors of vital importance to navigators in ice. Marine Radar will delineate the exposed edges of nearby ice floes but is unable to provide information on ice characteristics further a field. Further, beyond a range of about 3 nmi., there is little information in the image due to the rather low antenna height above the ice. Methods of downlinking SAR imagery in real-time from the aircraft to the ship have been available for sometime. In the last few years a shipborne receiving station and display system (STAR-VUE) has been developed, making it possible to view SAR imagery on the ship in close to real-time.

Although marine radar has no long range information to offer, by matching its image to the SAR data on STAR-VUE it is possible to locate the ship on the SAR imagery. Once positioned on the SAR imagery a strategic plan may be developed for the easiest and safest route to the intended destination. However, finding the position of the ship on the SAR imagery had been, prior to the completion of the work described in this report, a very arduous task.

1.2 The Original MARINE-VUE's Shortcomings

MARINE-VUE had been designed to overcome many of the short-comings of the standard marine radar display. Specifically, the standard display could only be viewed in the dark of a viewing hood, and the display had *only* a real time capability. That is, data were displayed as they came from the radar, and could not be preserved for study, for even a short time. To circumvent these two problems, a soft copy digital display was installed on the marine radar, and placed next to the SAR display (INTERA 1987). This was based on the digital scan converter made by Folsom Research of Folsom California. (See the Brochure in Appendix A)

This device has many of the needed characteristics to replace the standard marine display for use in navigation with SAR and marine radar. It has a digitizer in the front end that converts the radar data from analog to an 8 bit digital form. The system has both a digital output to a standard digital computer (GPIB), and a standard video output (RS 422) for display on an NTSC compatible colour monitor. Further, and of prime importance for the work described in this report, it is controllable from either a front panel key pad, or via an RS232 port, from another computer.

The digitization of the marine radar data and their display on a 'bright' display are only the first step in integrating the marine radar with the STAR-VUE system. INTERA, DFO and Canarctic had been using the Folsom Radar Scan Converter for several years and had exposed a number of short-comings. According to INTERA's research, the Folsom system provided the best available scan converter for MARINE-VUE at the time it was chosen. However, there were several features that were obviously lacking for use in a marine environment. These included:

1. A "stand-alone" interface that is easy to use for controlling all radar functions;
2. An interface to the ship's gyro for ship's heading mark;
3. An adjustable range and bearing cursor;
4. A front panel and computer control for intensity, gain and threshold;
5. Clutter removal circuits (STC, FTC); and
6. Range rings.
7. Scale and Bearing to match those of STAR-VUE.
8. Communications between MARINE-VUE and STAR-VUE to allow the transfer of data and control signals between them, and to allow the use of position fixes on the Marine Display to be transferred to STAR-VUE for position fixes.

In addition, several desirable features included user selectable scale settings beyond the ranges of 3, 6, 12 and 24 n.mi., a colour display, as well as some form of scan-to-scan averaging.

2.0 MARINE-VUE UPGRADES

In order to accomplish this work, the Folsom unit was upgraded with both new hardware and software, supplied by the manufacturer. In addition, a new front end video processor was fabricated (by INTERA) to complete the marine specific video processing tasks. Since the scan converter is physically isolated from the video display (where the operator normally sits), to ensure ease of use, a new operator's remote control panel was also built.This unit communicates directly with the scan converter over an RS-232 line, using a small micro-processor. A limited number of functions were also implemented that are controllable from the MARINE-VUE menu on STAR-VUE. Lastly, a new colour video board was installed in the TDC MARINE-VUE, to allow either colour or monochrome display. The system as proposed is shown below in Figure 1. In this system drawing, the dual polarised radar from CCIW is shown along with the normal ships radar, both fed through the RDS data distribution system, built by Canarctic, while the equipment to implement this configuration was provided, the CCIW radar has yet to be installed on the ship, and therefore the system, as shown, has not been tested.

To facilitate the integration of the dual-polarized radar a new radar video mixer was developed to combine the HH and HV radar data. Since both data streams result from a single radar transmission, they can be easily combined as analogue video. The output from this combiner can be either the HH or HV, or combinations (i.e., add, subtract ratio). This is described in detail in the Technical Reference Manual (INTERA 1988).

In addition, controls were developed to adjust the scale and aspect of the MARINE-VUE image. This is controlled directly from the STAR-VUE screen. This will allow for the best possible image-to-image correlation. Data storage, for post-voyage analysis, can also be done using the STAR-VUE system and it's tape drives.

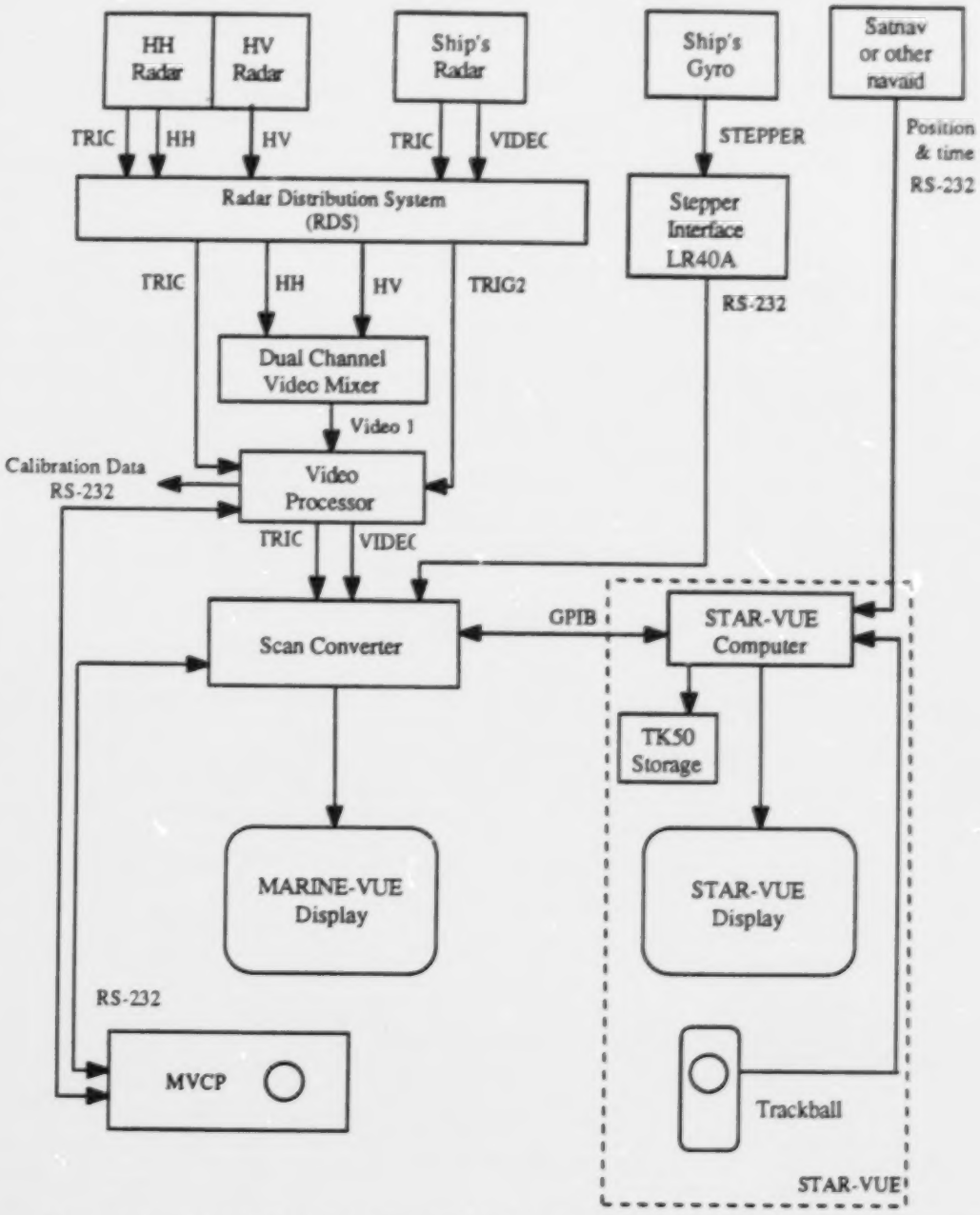

Figure 1. The Original Proposed MARINE-VUE Configuration

2.1 TDC and CCIW MARINE-VUE Upgrades

Specifically, the following additions were added to the CCIW Folsom and to the TDC Folsom unit located on the M.V.Arctic:

1. Differential Synchro

   The unit can now accept ship's gyro compass input to allow a continuous "north-up" display as an option to the currently available "heads-up". An operator-actuated heading marker is also available.

1. Marine Type Cursor
   A live cursor with continuous readout of range and bearing was added, along with range rings, in nautical units and an azimuth bearing ring.

2. Noise Suppression
   Returns that are both very strong, and exist for only one radial are, for the most part, interference from other radars. These can be "black holed" according to the standard marine practice.

3. Colour Board
   The output of the was modified with a colour look-up table on the video output. This provides an RS-170 RGB signal.

4. Radar Video Processor
   A new video processor was built to process the radar video. It has all functionality controlled by the main Folsom processor. Local circuitry is controlled by a microprocessor. The functions that are implemented are:

   a. STC (Sensitivity Time Control)
      Range dependent gain, using a law handed down from the main CPU.

   b. FTC (Fast Time Constant)
      A fast time constant circuit, controlled by the CPU, to allow rain returns, etc., to be largely eliminated.

   c. Gain and Offset
      A digitally controlled gain (0 to +20db) and a digitally controlled DC offset (+/-20% of scale) to maintain standard scale.

6. MARINE-VUE Control Panel

The Folsom scan converter is controlled via a control panel on the front of the unit, or via an RS-232 port. Both communicate with the CPU,which then implements the desired changes to system operation. For operator convenience, a "marine" type control of the entire MARINE-VUE system is now available and can be located at the NAV-ICE console. This communicates with the scan converter CPU via an RS-232 line. A small microprocessor is used in the control panel to convert the control signals to RS-232 signals. Functions which are controllable area:

i) Range - 3, 6, 12, 24 nm miles;
ii) Video Gain - 0 to 20 db (2db steps);
iii) Video Offset - 0 to + 20%;
iv) Orientation - 0 to 360° offset from head/north-up;
v) STC - Threshold;
vi) STC - Time constant;
vii) FTC - On/off;
viii) Trackball, range and bearing cursor (over entire screen);
ix) Trackball, PPI origin (over entire screen); and
x) STAR-VUE control indicator (on/off).Control of the scale, orientation, and x, y origin can be given over to STAR-VUE.

7. Additional Features

During tactical navigation, it is necessary to locate the position of the ship on the SAR to match the MARINE-VUE image to the STAR-VUE image. This is greatly facilitated if the images are both of the same scale and orientation. This function has been implemented as part of the MARINE-VUE upgrade.

The SAR flight lines are typically not flown to optimize a "north-up" display. Therefore, it is necessary to rotate the MARINE-VUE image to match the SAR. If a north-up display is on the MARINE-VUE, and STAR-VUE knows the SAR orientation, STAR-VUE can command the marine image to be rotated to match. Similarly, the marine image scale can be modified to match the STAR-VUE scale. In this way, the operator can command STAR-VUE to produce a customized marine display that will match the SAR image. Some fine tuning of the orientation is allowed, to account for ice drift since the SAR data were collected.

8. Logging of SAR/Marine Data

The STAR-VUE and MARINE-VUE images are correlated by the ship's operator, as part of the tactical navigation task. It is proposed to take advantage of this record by logging appropriate SAR/marine radar pairs for later analysis and training. The operator, once on image has been correlated, can with a single command, store both a SAR frame and the appropriate marine image, at the same scale and orientation. This is accompanied by appropriate header information needed to interpret the imagery.

3.0 MARINE-VUE UPGRADES CONSTRUCTION AND INSTALLATION PHASE

In the late summer of 1987, INTERA began construction of the hardware, and the development of the software for to accomplish the needed upgrades to the Folsom box. Two sub-contracts were let; one to a Calgary firm, Champ-Armstrong for the Dual Channel Video Mixer (DCVM), and the second to Folsom Research Inc. for software and hardware upgrades. In Parallel, INTERA began the design and upgrade for the Control Panel, (CP) and the Video Processor (VP). The software for the control panel was all embedded in a microprocessor, and was written in FORTH. The STAR-VUE upgrades were all written in C. The details of the upgrades, including the software listings, are documented in the Technical Reference Manual, previously supplied to (TDC INTERA June 1988).

The installation on the MV.Arctic was accomplished late in the season of 1988 in time for the late fall voyage of the MV Arctic. The installation relied heavily on Canarctic personnel, as they were very familiar with the requirements of the installation and operation of the MARINE-VUE. Documentation of of both the Folsom Box, and the INTERA fabricated hardware was provided to Canarctic for the installation. An operators manual was also provided, and is included in Appendix B. An INTERA engineer accompanied the ship on the inbound trip from Europe, to ensure proper operation of the system.

4.0 RESULTS OF THE NOV-88 VOYAGE

During the November 1988 voyage of the MV Arctic into and out of the Arctic, the MARINE-VUE was evaluated by Canarctic Personnel (Canarctic 1989). This report forms the basis for the evaluation of the MARINE-VUE upgrades. On the whole the field trial was very successful, as the equipment performed well, and was judged to be overall, very useful. There were however, a number of recommendations for changes and upgrades to the system.

Two main problems arose with the hardware that needed correction. Firstly, the Folsom Scan Converter proved to be incapable of handling the highest PRF from the ships radar. On the shortest range, the DECCA Radar has a 50 nsec pulse and a 3600Hz PRF. This is well beyond the maximum PRF of 2000Hz that the system is capable of handling. It was necessary to devise a divide by two circuit that eliminated the problem.

The second problem that arose was the inability of the Colour Board in the Folsom unit to drive the local video monitor. Since the system is normally used in monochrome mode, this was not a serious problem. It was later rectified by a replacement board from Folsom Research.

The evaluation of the system by Canarctic shows that the availability of a 'Standard Marine' type of user interface was very well redeived by the ships crew. In particular the Video Gain and STC Curves were used with regularity. However, the analysis concludes that much more work is needed to arrive at the correct levels for the STC corrections.

The analysis of the other controls such as Range and Bearing, Overlays etc, concluded that they were accurate and well received. The only comment was that the inner range ring should be independently turned on and off from the rest of the range rings.

The STAR-VUE Functions that were upgraded were not as warmly received as the hardware upgrades. In large part this seems to be more a comment on the failure of the STAR-VUE system to operate reliably and efficiently during the voyage. On the inbound trip there were errors in the parameter file being used to convert the downlink received data, and on the outgoing voyage there was a fatal hardware failure of the STAR-VUE. None the less it is possible to arrive at some conclusions from the experience.

There were two main functions evolved for the STAR-VUE; auto scaling, and position fixing. These were both tested and reported on by Canarctic.

The auto scaling worked exactly as planned, but was not popular with the ships crew. In this mode, the scale and orientation (rotation) of the MARINE-VUE display is controlled from STAR-VUE, and made to match the scale an orientation of STAR-VUE. This proved to have two main drawbacks. First, the data being delivered to the MV Arctic from STAR-1 had been reduced to 24 metre pixels to facilitate their rapid use. At this scale, the MARINE-VUE display is rather poor, as the outer part of the screen contains no useful data. This is a serious problem as there is little that can be done, short of putting the ships radar on a tall mast, to improve the range of coverage from the marine radar. A second problem is that the ships crew was unwilling to have the MARINE-VUE display in other than the standard North-Up mode.

Both these problems are in principle easily corrected. The basic data transmitted by STAR-1 are at either 6 or 12 metre resolution, depending on the mode of the radar. The downlink used for service to the MV Arctic would need to be upgraded to handle the higher data rate and the disc would need to be exchanged for the larger models used on the CCG vessels, but this hardware, and the software to operate it has been developed and delivered to the CCG. Further, the STAR-VUEs used by the CCG are all operated in a North Up mode, with the data rotation in the active navigation window. Therefore the MARINE-VUE rotation would be only used to estimate the degree of rotation of the ice in the interval between data collection and the interpretation on STAR-VUE. It could therefore be argued that these particular problems encountered in the November 88 voyage of the MV Arctic have been overcome.

The problems and shortcomings associated with the navigation functions on MARINE-VUE/ STAR-VUE are less clear and more difficult to address. The interaction planned and implemented during this study were aimed at using the marine radar imagery, displayed on MARINE-VUE, to provide position fixes on the STAR-VUE display. Triangulations allow the fixing of the ships position by a series of control point matching on the MARINE-VUE and STAR-VUE displays. The ship could then be 'centred' in the STAR-VUE image. The operation of all these functions, while in some cases more awkward than they should be, was generally complete and accurate. However, there was a general feeling that STAR-VUE was a bit too slow and difficult to use and that these disadvantages outweighed its advantages, when compared to the method of using hard copy imagery which has been developed over the years.

There were a number of specific small changes to the system recommended, that will be rather easy to implement. These include

1- The softcopy keypad was found to be very awkward. (In the CCG version of STAR-VUE, been replaced by a standard keyboard.)

2- The STC curves were not matched to the ice reflectivity and radar performance on the MV Arctic. (INTERA relied on data from CCIW for these curves. It was identified in the build stage that the curves were a first estimate, and that data should be collected on the record pairs to establish new curves. These can be relatively easily burned into the chips in the MVCP).

3- The FTC function appears to introduce too much high frequency noise. (It was recognized that this would need some interactive 'tuning' during a field trip when rain and or snow were present. None were encountered on the November 88 voyage to allow this adjustment.)

4- The interior range ring should be made to be independently disabled. (This would be a rather minor change in the Folsom software, but would require an additional control function to be installed on either the STAR-VUE panel, or the MVCP.)

5- Query MARINE-VUE should not require the operator to reselect the menu option but should stay for additional segments, which are regularly required. (This minor software change has been noted for inclusion in the next version of the software released to Canarctic.)

6- Mark Ships Position had a slight error in the location of the cursor. (This has been rectified.)

7- The text on the Comment Option is too small and should be enlarged. (This has been done.)

8- Centre Ships Image should allow the ships position to be placed at either the top or bottom of the image, depending on the direction of travel. (This request has been noted. However, the current CCG version of STAR-VUE has a substantially faster disc and CPU and therefore the objection to a slow update is now of less concern.)

9- It was recommended that an upgraded Scan Converter be investigated, as a replacement for the now aging technology of the Folsom Unit. (INTERA and Canarctic have identified several potential units. This is discussed further below.)

10-The colour Board on the Folsom unit failed to give proper colour. (This has been replaced by Folsom.)

11- Canarctic recommended that the PDP-11/73 be replaced on the STAR-VUE system. (This has been addressed in the CCG version with the upgraded PDP-11/83, and INTERA is investigating newer systems based on Limited Instruction Set, Transputer, and other high speed computer technologies.

5. FUTURE MARINE-VUE PROGRAM

Outlined below are INTERA's recommendations and suggestions regarding the future activities for marine radar development. These activities focus on the continued development of MARINE-VUE for the ice application. We see the program having 3 major components:
1. The evaluation and refinement of the current MARINE-VUE prototype.
2. Evaluation of recently available hardware systems and scan converters and
3. Further R&D to reduce operator workload while using the STAR-VUE/MARINE-VUE systems for tactical navigation. This includes the investigation of aids to improve the task of image to image correlation.

5.1 MARINE-VUE Evaluation

From the above summary it is clear that a great deal of work has been done during the past year to upgrade the MARINE-VUE system. MARINE-VUE has recently been tested on the M.V. Arctic. However, this evaluation was primarily qualitative. It uncovered two areas of concern, the STC and FTC where it will be necessary to do quantitative evaluations of the system. INTERA feels a complete quantitative evaluation of the system would result in an improved design specification for the next generation of MARINE-VUE, if indeed there is to be one. INTERA also feels that this may also be a good time to bring CCG into the program as well thereby ensuring that their requirements are well understood. This is especially true now that the CCG is fitting their ships with STAR-VUEs.

5.2 Recent Hardware Evaluation

Since the Folsom scan converter was purchase several hardware manufacturers have developed new products. For example a new system is being developed by Canadian Marconi., and a new scan converter manufactured by Cross-Bow. INTERA feels that it is important to evaluate these new systems as potential replacements for the Folsom Box in the MARINE-VUE SYSTEM. Initially a technical study should be conducted to evaluate these new products. This may be followed by shipboard testing and integration with STAR-VUE. INTERA is prepared to undertake this study.

Dual polarized radar systems are now being tested on the M.V. Arctic. These systems provide new sources of data and may require the development of new display boxes. Although INTERA will unlikely be involved with the radar hardware development, we feel that it is important that the display portions of these systems fit within the STAR-VUE concept to result in integrated systems. We would like therefore to be directly involved with the display portion of these new systems.

5.3 Future R&D

INTERA feels that now is a perfect time to undertake further study in the use of the integrated MARINE-VUE/ STAR-VUE systems. We feel that it is important to examine the issue of operator workload, particularly with respect to to the task of tracking the ship's progress on the SAR image with the marine radar image. (Recall this was a very controversial point with CCG). Although much has been done to allow the operator to rotate and scale images with the recent hardware changes, INTERA feels that several additional aids could be provided to improve this task. Areas that should be investigated include:

1. Provision of tools based on the ship's navigation system or other information to assist tracking.

2. Provision of tools to aid in the task of image to image correlation. For example simple outlines occupying a single bit plane of shapes and patterns taken the marine radar image could be superimposed onto the SAR imagery on STAR-VUE. A facility could be easily built to move these bit plane images about on the SAR. INTERA is currently building such a facility for AES to allow map overlays to be superimposed on the SAR.

3 Auto-tracking tools based on conventional pattern matching techniques should be investigated. The system installed on the M.V. Arctic is now capable of collecting data sets of SAR and Marine Radar pairs which are the same scale and orientation. This has always been a limiting factor in applying this approach in the past. INTERA has done early experiments at simulating the marine radar data from SAR. This could greatly improve the speed with which the pattern matching task could be done.

4. In addition to investigating conventional pattern matching techniques new knowledge based techniques should also be studied. This is a logical extension of work that INTERA is currently undertaking for the SAR interpretation program which identifies important features and patterns in the ice imagery. Identification of similar features could improve the image correlation problem between SAR and Marine radar data and significantly reduce the processing time required for matching. Knowledge-based image understanding systems are now widely used for the interpretation of remotely sensed data.

6.0 CONCLUSIONS

The prime purpose of the work described in this report was to develop a 'Mariner Friendly' softcopy MARINE-VUE display that was integrated into the STAR-VUE display. To a very great extent this has been accomplished and has demonstrated the practicality and utility of such a display. Further, the primary criteria for any further work in this area, and for future developments has been established.

7.0 REFERENCES

Canarctic Shipping Company Ltd.(1989)
Field Evaluation of TDC/INTERA MARINE-VUE Upgrades -Final Report
Transport Canada File No. D1460-238-7 March 31 1989

INTERA Technologies (1988)
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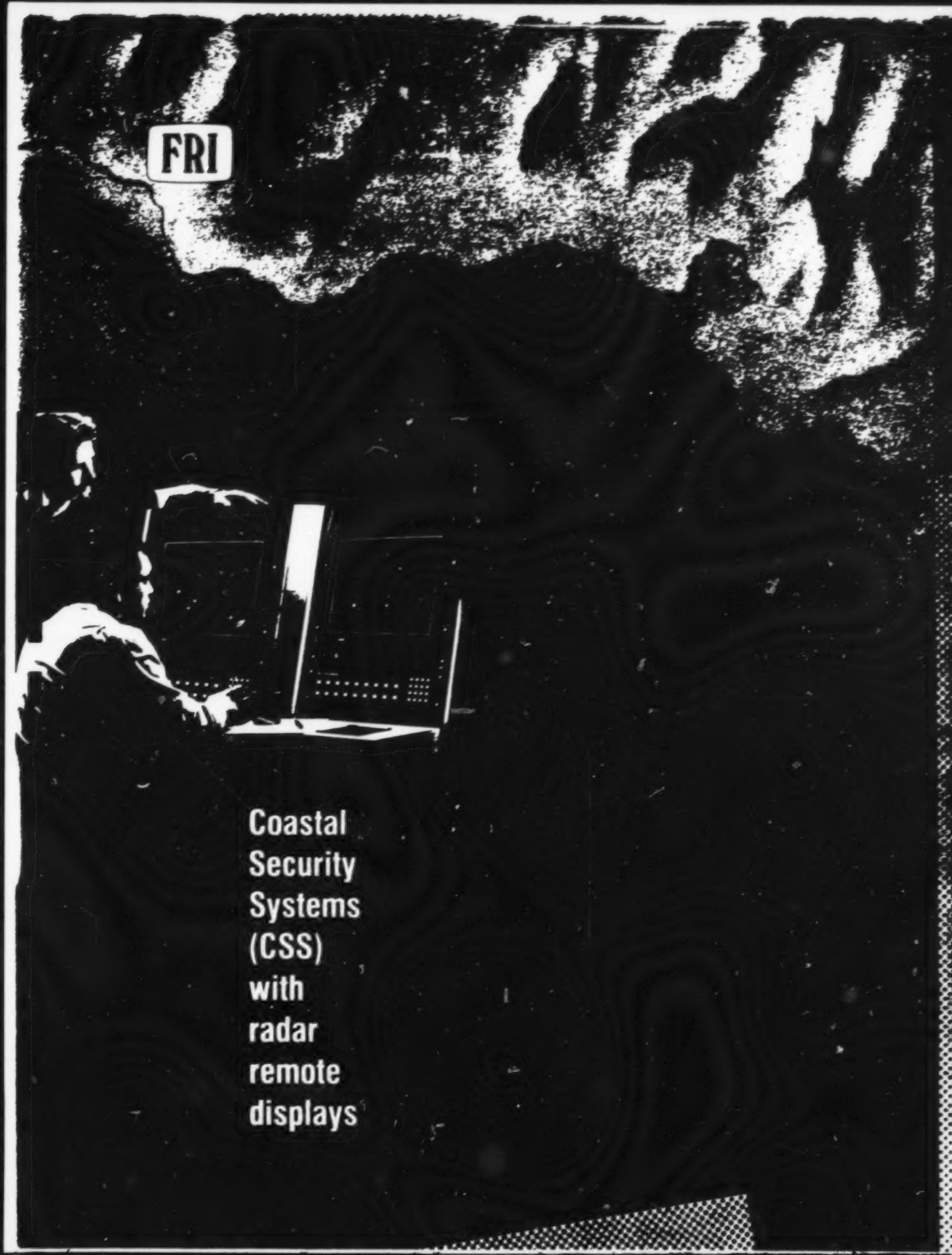
INTERA Technologies Calgary, Alt. June 1988

INTERA Technologies (1988)
Technical Reference Manual for MARINE-VUE - C323
INTERA Technologies Calgary, Alt. June 1988

APPENDIX A

FOLSOM RESEARCH SCAN CONVERTER BROCHURE


FRI
Coastal
Security
Systems
(CSS)
with
radar
remote
displays

Folsom Research Incorporated now makes it possible to utilize a series of radar installations to monitor your entire coastline 24 hours a day from a central location. Fast moving, quick maneuvering vessels attempting to avoid detection, even low flying light aircraft, may be outmatched by this breakthrough in coastal security.

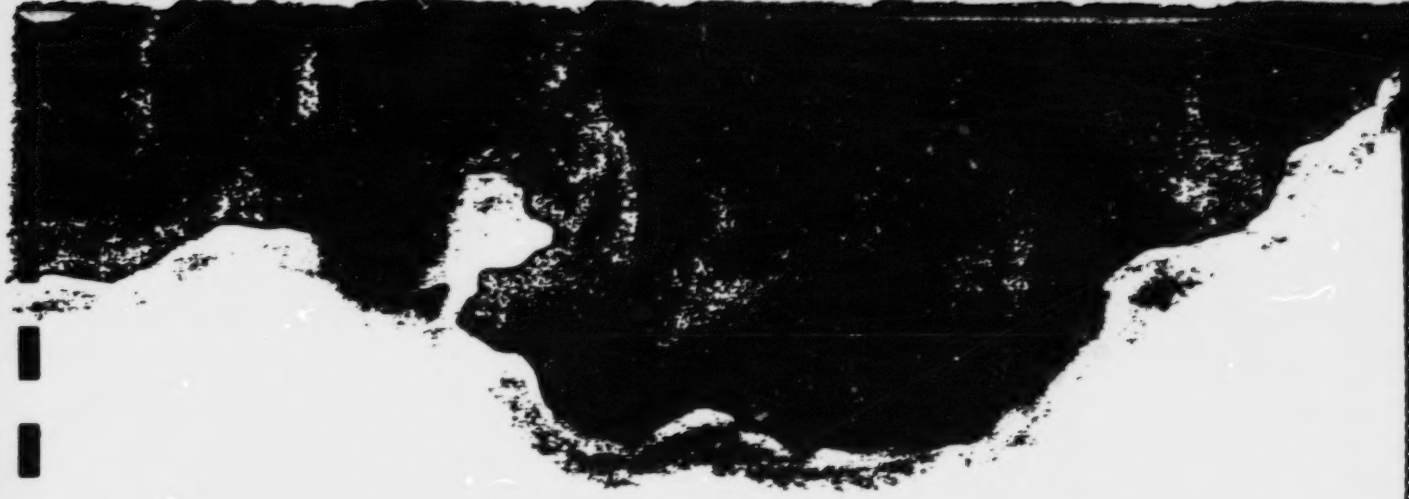
The favorite target of drug traffickers, the coastline is vulnerable to violation by criminal elements. A constant vigil must be maintained in an attempt to discourage illegal entries, illegal fishing, even military aggression. Until now, there has been no effective way to monitor this activity.

In answer to this dilemma, Folsom Research Incorporated has introduced Coastal Security Systems (CSS). These systems make it possible to select marine vessels and light aircraft appearing on the radar monitor, and to track them tenaciously. Bearing and speed can be shown, and interception courses immediately calculated. Converting radar signals to digital information, this technology also allows the view on each monitor to be transmitted (via ordinary telephone lines or radio transmissions) to a central command site where target information can be coordinated and supplied to interceptor teams.

Vessels illegally entering your coastal waters will be subject to the scrutiny of a highly efficient tracking system ... a major step toward the protection of your coastline.

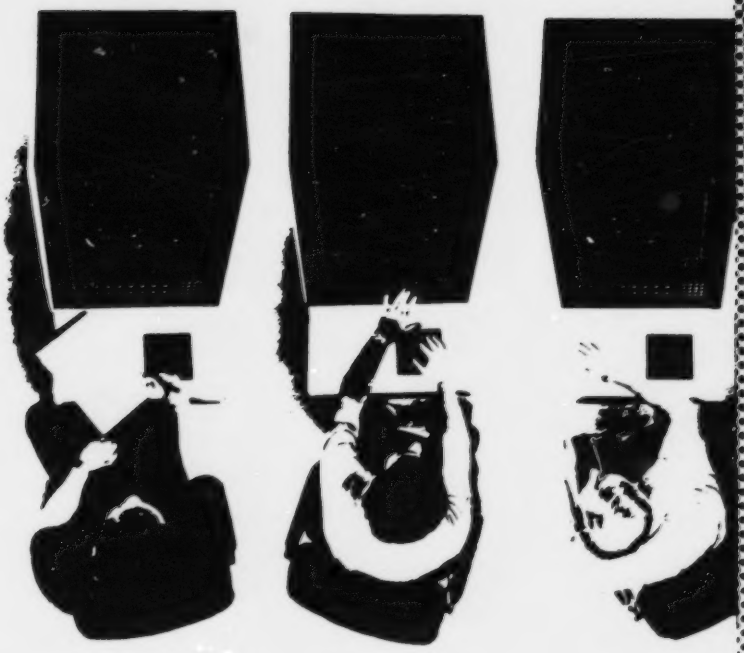
System Features

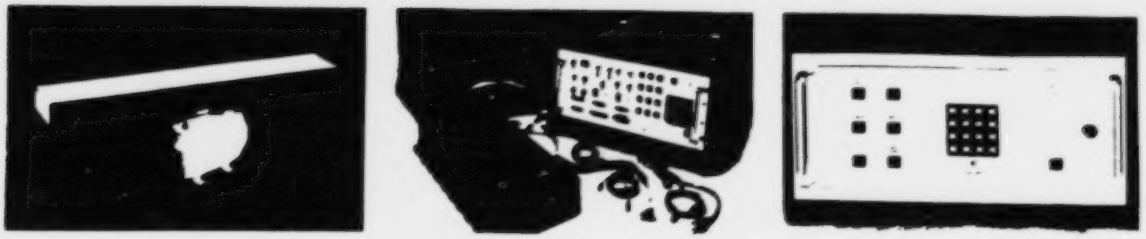
- **Remote Monitoring and Control**
  All scan converter and display function commands are made at the command center by remote control. Remoting range is unlimited.
- **Tracking**
  Tracking of up to 15 maritime targets. 60 targets optional per radar installation. Calculates speed and course for interception.
- **Map Graphic Overlays**
  Multiple maps can be designed and stored in the system, then overlayed instantly upon command. Unlimited messages can be programmed for display as text overlays. Date and time message may be included.
- **Programmable Fade**
  Fade may be operator controlled to provide target trail ranging from as long as 15 minutes to as short as 1 second.
- **Digital Image Memory**
  Allows frame-to-frame averaging to reduce noise and random signals, reduce clutter and highlight moving targets.
- **Radar Video Digitizer**
  The system provides 64 digital levels of gray providing smooth fade and trail for tracking.

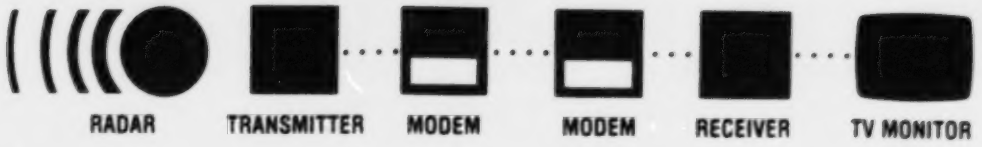


- **Recording Capability**
  Radar display information can be recorded on standard video tape recorders. Up to 24 hours of radar traffic history can be stored on a 20 minute cassette.

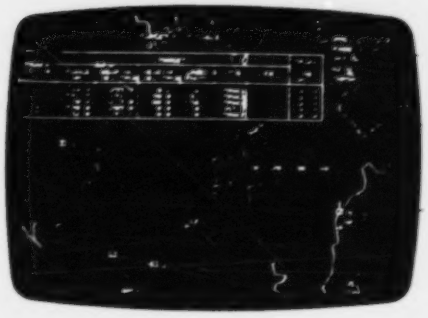
- **Economy**
  Initial investment is substantially lower than with less advanced technology. Easily installed, inexpensive lightweight marine radar units may be used. With central monitoring and unmanned coastal installations, personnel requirements are reduced, effecting further economies. Few internal adjustments of the system are required, thereby providing years of maintenance-free operation.







TYPICAL SCREEN IDENTIFICATIONS



Coastal Security Systems (CSS) with radar remote display and control modules are economical yet ultra sophisticated by-products of advanced scientific research. Especially applicable to vessel traffic monitoring, these systems enable tracking of targets with any radar, and provide target plotting, overlay maps, and calculation of bearing and speed.

Each system contains two major hardware items working with compatible radar scanning units. First, a Radar Scan Converter unit at the radar or transmit site, which converts radar video data into TV video for display or recording. The Scan Converter also enhances target images and reduces the effects of clutter. Fade-rate, range, freeze, intensities and offsets are programmable either directly or by remote control.

Secondly, a Remote Processing and Control Unit is located at the central control or receive site. Connected to it are a trackball assembly to move the cursor, a Remote Control Unit which contains the function keys for selecting and controlling display, tracking, and plotting, and a built-in interface for an optional host computer.

As the tracked target plots are updated with each scan of the radar, a separate message for each target or plot is sent with the radar video scan. Once selected for tracking, the system computes and plots the target's position and sends updates to the display console whenever the taget has changed position, providing instant information for surveillance or interception operations.

System Description

- Transmitting Scan Converter (8342 TX)
- Receiving Scan Converter (8342 RX)
- 25 KW X-band, 8-10 ft Radar Set
- High Speed Transmission Modems (2)
- Operator's Console with Operating Panel, Trackball and 15" Monitor
- Complete Operating Software Package
- Installation, Operating and Maintenance Training at FRI
- Complete Documentation
- 90-day Warranty (Extended Warranty available)

System Specifications

- Size & weight (RX TX unit)
  19" standard rack mount x 8¾" [height] x 20" [depth]
  Weight 39 lbs.
  Temp 0°C-45°C
- Power requirements (excluding radar)
  110÷ -10 vac 50-60 Hz
  300 watts
  220÷ -20 vac 50-60 Hz
  300 watts
- Approximate 25 mile radius coverage per radar installation
- Display range variable from 2 to 250 miles

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THE PIONEER IN DIGITAL SCAN CONVERTERS

INTRODUCTION

Complete in-house capability for Digital Scan Converters:

- ☐ Design
- ☐ Development
- ☐ PC Board fabrication
- ☐ Manufacturing, Assembly and Test
- ☐ Systems Integration and Test

Developed FIRST Real-time, Digital Scan Converter in 1976.

Designs, develops and builds special digital imaging systems.

Business is 40% Military/Government, 60% Private Sector.

Small Business Administration Sub-contractor of the Year in 1983.

FACILITIES

Located in historic gold mining town of Folsom, California, 20 miles east of Sacramento.

12,000 sq. ft. facility on two acres (all owned).

- 8000 sq. ft. for fabrication, assembly, test, and production.
- 4000 sq. ft. for engineering, administration, and management.

8086/8087 multi-user, multi-tasking software development system.

Existing production capacity for 30 scan converters per month.

Complete in-house printed circuit board design/fab capability.

STANDARD PRODUCTS

8342 RADAR SCAN CONVERTER and DIGITAL DISPLAY PROCESSOR converts radar video to digital image and outputs: RS-170 video for display and recording; IEEE-488 digital from freeze frame for computer analysis and RS-232 Slow Scan.

8350 DIGITAL RADAR SCAN CONVERTER and DISPLAY PROCESSOR accepts high speed (42 MHz) digital radar data from radar signal processor and generates an RS-170 raster video display including display offsets.

8359 RADAR SYMBOL GENERATOR and TARGET SIMULATOR generates programmable radar symbology, and targets tracks for output to PPI (X-Y) displays. Input is RS-232 commands.

8430 VIDEO SCAN CONVERTER and IMAGE PROCESSOR converts 875 line, RS-343 video in real-time to 525 line, RS-170 video. Includes image enhancement functions, three conversion modes and time base correction for video tapes.

8230 VIDEO SCAN CONVERTER converts 1075 line, RS-343 video (computer generated tactical map display) to 525 line, RS-170 video including 2x and 4x zoom functions.

8340 VIDEO LINE SYNC GENERATOR enables selection and output of any line of video from video signals up to 1023 lines.

GENERAL INFORMATION

1. Folsom Research Inc. (FRI) is a small business, FSCM058761, and is the facility where all products are manufactured and tested.
2. Folsom Research Inc. (FRI) employs less than 50 employees.
3. Prices quotes are firm for a period of 90 days.
4. Prices are FOB factory and are NET 30 days for standard products.
5. DUNS No. 09-690-2796.
6. FRI is an Equal Opportunity Employer, and does not maintain any segregated facilities.
7. All FRI products carry a 90 day limited Warranty for material, workmanship and labor. Maintenance and repair, as authorized, is performed at FRI.
8. Published price lists and catalogs exist for all standard products.
9. Folsom Research Inc. warrants that the prices of the standard products in the published price lists are the same as those prices charged by FRI to any other commercial or government customer purchasing the same item in comparable quantities.

SERIES 8000, MULTIFUNCTION DIGITAL SCAN CONVERTER

Every Series 8000 scan converter has four functional, common modules:

Input Processor	A 6-bit A/D flash converter is standard (8-bit optional). Video (8430) module accepts video bandwidth to 27 MHz. Radar (8342) module accepts radar or line scan bandwidth to 5 MHz.
System Controller	An 8086 based 16-bit CPU that provides master control and system interface functions. Contains (2) RS-232 and (1) IEEE-488 port. Also controls look-up tables in INPUT and OUTPUT processor modules. Optional 8087 co-processor can provide 32-bit arithmetical operations such as 32-bit fixed or floating point multiply and divide.
Memory Module	A high speed 512 x 512 x 9-bit image memory with nibble mode RAMs. One 1-bit image plane is dedicated for graphic overlays, cursors, annotations, video insertion and messages. Image memory is programmable into one or two memories for image processing functions.
Video Output Processor	An 8-bit D/A converter that generates the 525 line, RS-170 output video. Includes look-up table functions for image processing and contrast enhancements, plus provisions for an external sync.

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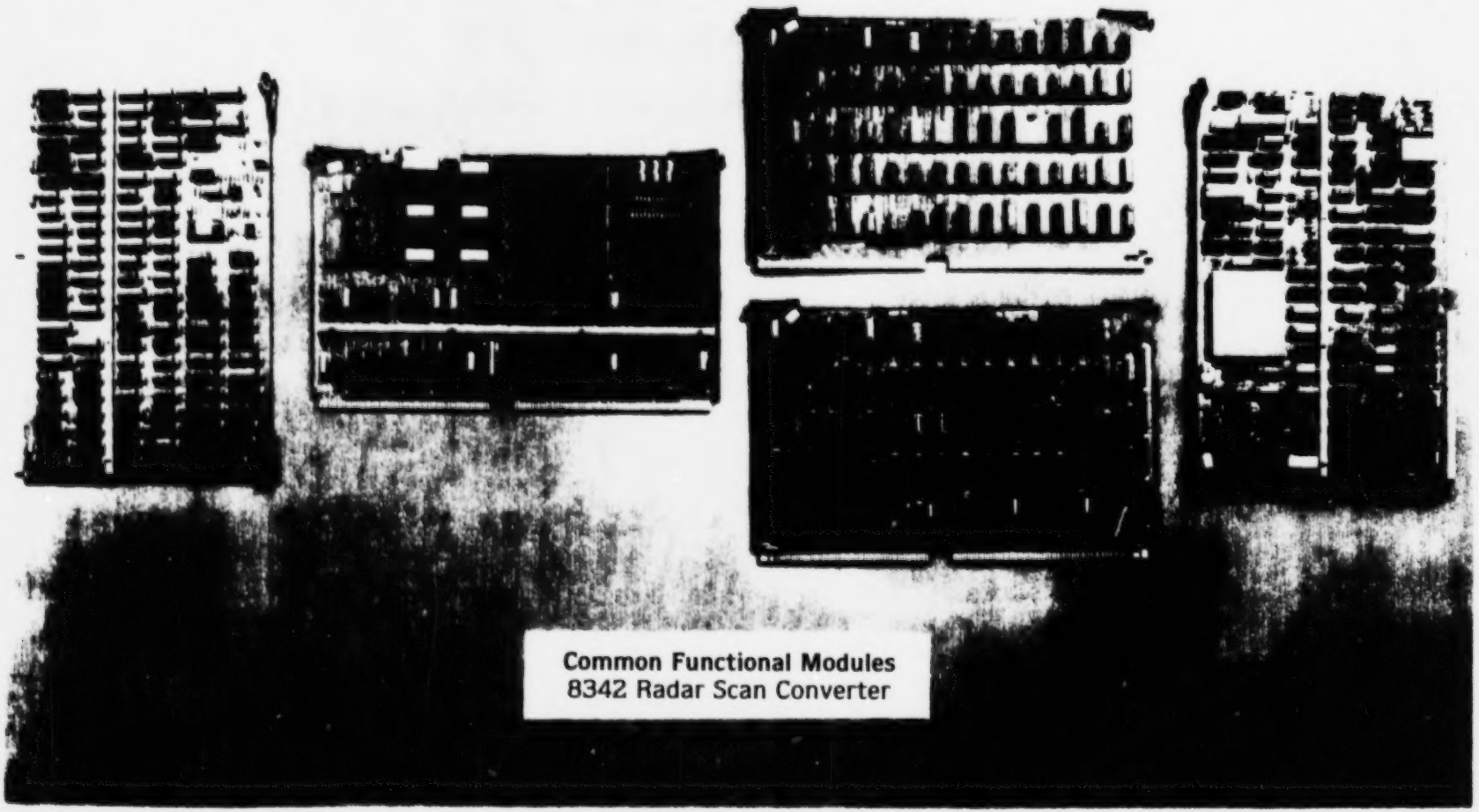


Common Functional Modules
8342 Radar Scan Converter

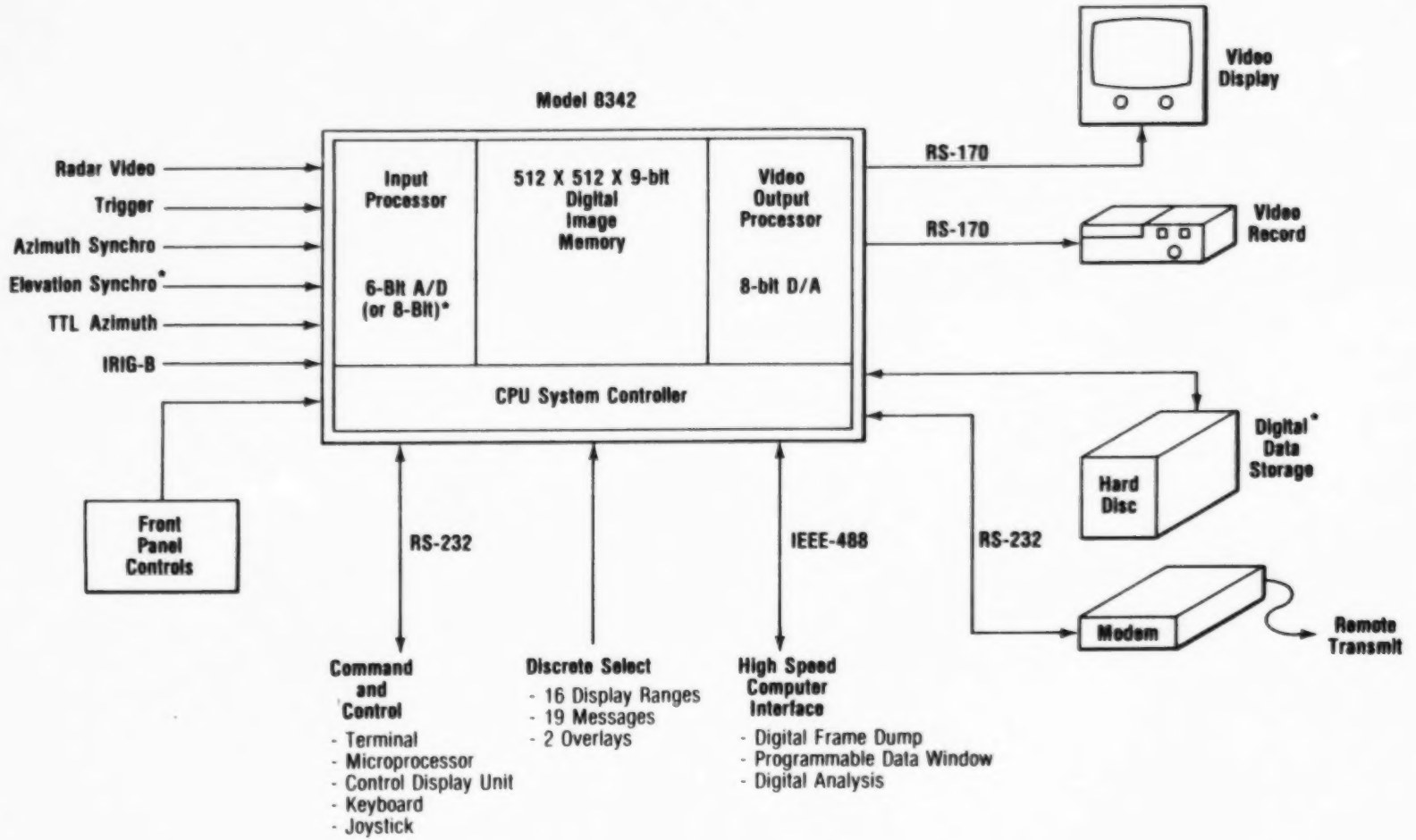
FRI FOLSOM RESEARCH INCORPORATED

RADAR SCAN CONVERTER, MODEL 8342

Converts live radar data to a digital image and provides 3 outputs.

Outputs:	525 line, raster video (RS-170).
	Serial telecommunications (RS-232).
	Parallel high speed digital (IEEE-488).
Inputs:	Radar video, azimuth and trigger (to 4 KHz).
Image Memory:	512 x 512 x 9 bits.
Display Features:	Frame freeze radar image for output.
	Image enhancement functions via software.
	Display offsets to improve data resolution.
	Programmable fade and trail.
	Built-in map and overlay graphics.
	Optional image subtraction or integration.
	Optional digital video integration processing.

Radar Digital Scan Converter



*optional

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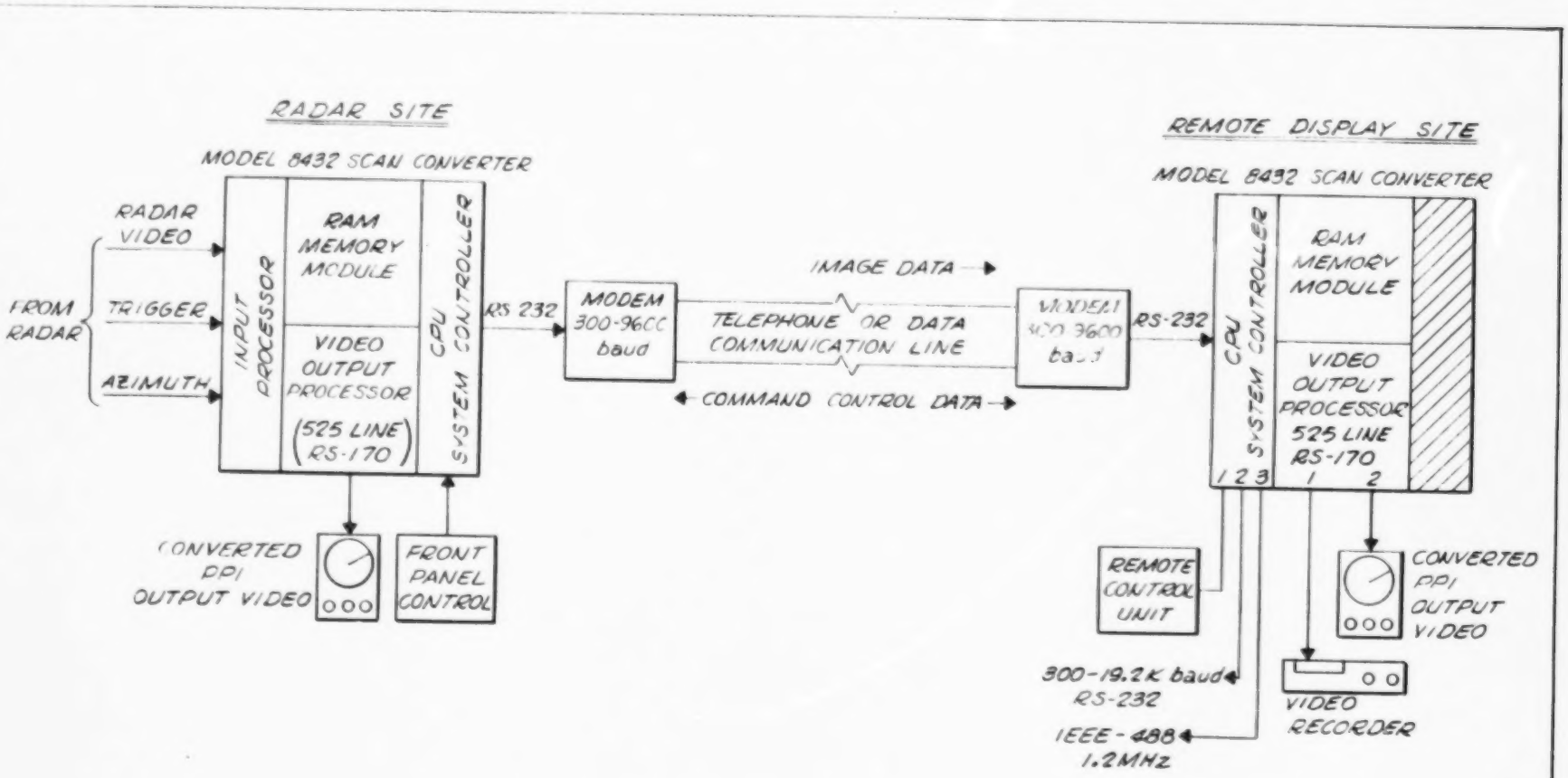

RADAR REMOTE DISPLAY SYSTEM

8410002 3/85

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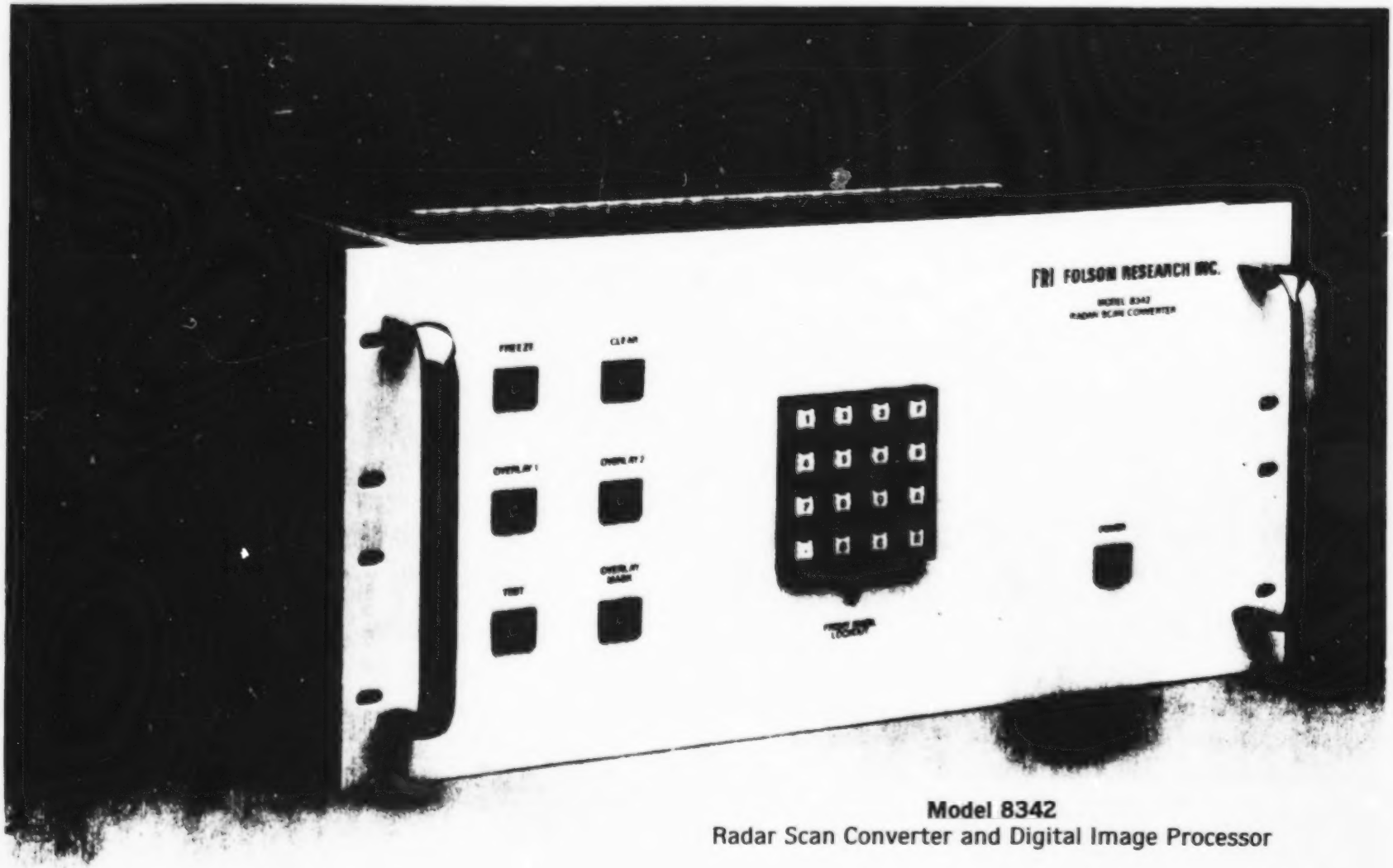
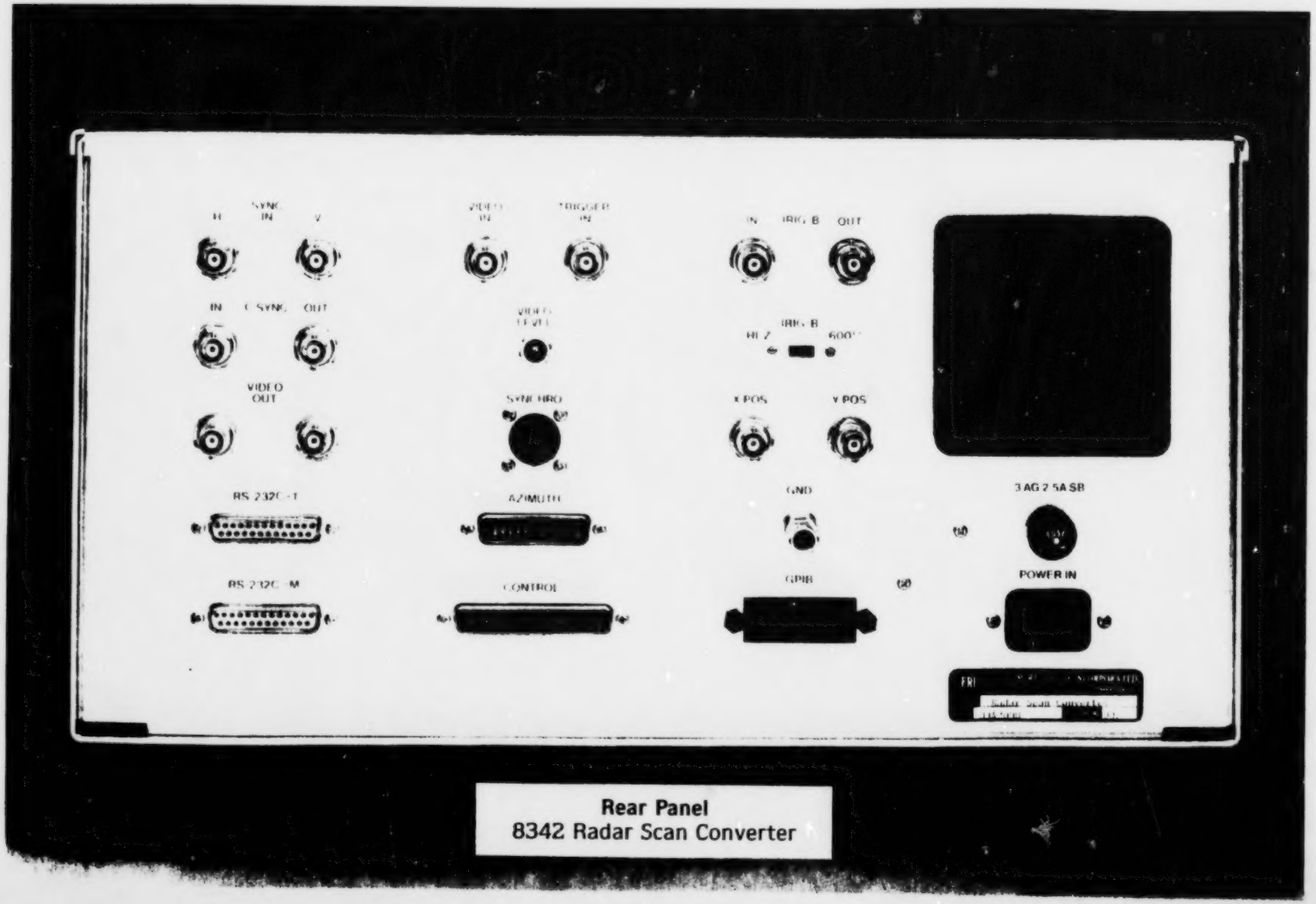


Model 8342
Radar Scan Converter and Digital Image Processor



Rear Panel
8342 Radar Scan Converter

RADAR SCAN CONVERTER: APPLICATIONS

Digital Display Analysis	Digitized image can be enhanced in real-time and input to a computer via IEEE-488 port for further analysis.
Video Display & Recording	Record real-time radar performance on video tape. Record freeze frame digital images for sequential playback and image analysis.
Remote Display System	Display scan converted radar image at remote location on TV monitors via narrowband telecommunication line using freeze frame RS-232 output.
PPI Display Upgrade	Replace old PPI displays with high contrast, raster video displays with digital refresh image. Scan converted image provides capability for freeze frame, programmable fade and trail, image and target enhancement.

APPENDIX B

MARINE-VUE USER'S MANUAL

MARINE-VUE
User's Manual

INTERA Technologies Ltd.
Calgary, Alberta

June 1988

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1.0 Introduction

With the advent of year-round shipping activities in the Canadian arctic, a need exists for a marine radar system that is optimized for the detection and display of tactical ice information. Canadian Coastal Inland Waters (CCIW) has developed a dual polarized radar system that has proven to be very useful in ice navigation, not only as the prime detector of ice hazards but also as an indication of the ship's position on airborne radar imagery. INTERA Technologies Ltd., under contract with the Canadian Transport Development Centre (TDC) has advanced a new generation of the MARINE-VUE system to provide the ship's operators with a valuable tool in ice navigation.

The requirements for a marine radar display in a tactical ice navigation work station have been evolving since 1979, when work began in the Canadian Beaufort. The focus in recent years has been on the M.V. Arctic with the Canarctic Shipboard Ice Navigation Support System (SINSS), the CCIW dual polarized radar, and the TDC sponsored work under the Multitask Image Data Analysis project (MIDAS, later referred to as NAV-ICE). This work originally concentrated on getting high quality airborne and satellite radar imagery onto the ship's bridge in the most useable fashion. The emphasis now has shifted to the development of a complete integrated ice navigation work station, including data from the original sources as well as the ship's radars. The airbourne radar component now in use is called STAR-VUE, and the satellite system is referred to as View-Fax. MARINE-VUE provides significant real time information for use during tactical ice navigation situations. The system's primary function is to provide integration of various subsystem controls. This allows users to easily display data from the various sources and manipulate several display parameters for improved viewing.

The complete MARINE-VUE system consists of a Dual Channel Video Mixer (DCVM), Video Processor (VP), MARINE-VUE Control Panel (MVCP), Scan Converter (SC), and STAR-VUE Computer. The MARINE-VUE system block diagram is shown in Figure 1. If a second radar is not being used, the system does not include the DCVM and is configured as shown in Figure 2. Figure 3 is a simplified cabling diagram of the entire system.

This manual is a user's manual for the MARINE-VUE Control Panel and Video Processor only. Specifications for the two units are contained in section 2. MARINE-VUE Control Panel functions are described in section 3. Section 4 contains a description of the Video Processor functions.

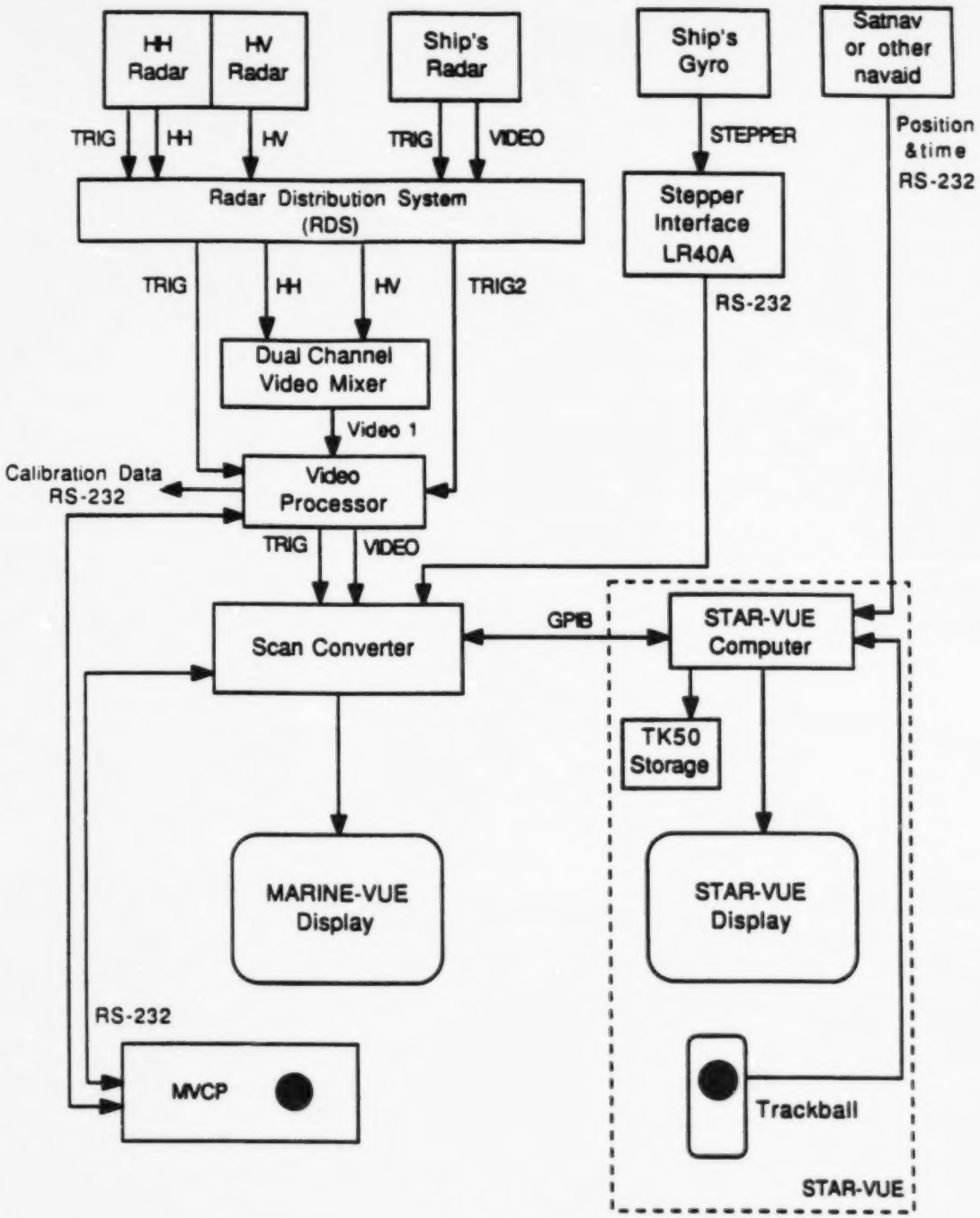


Figure 1. MARINE-VUE Integration

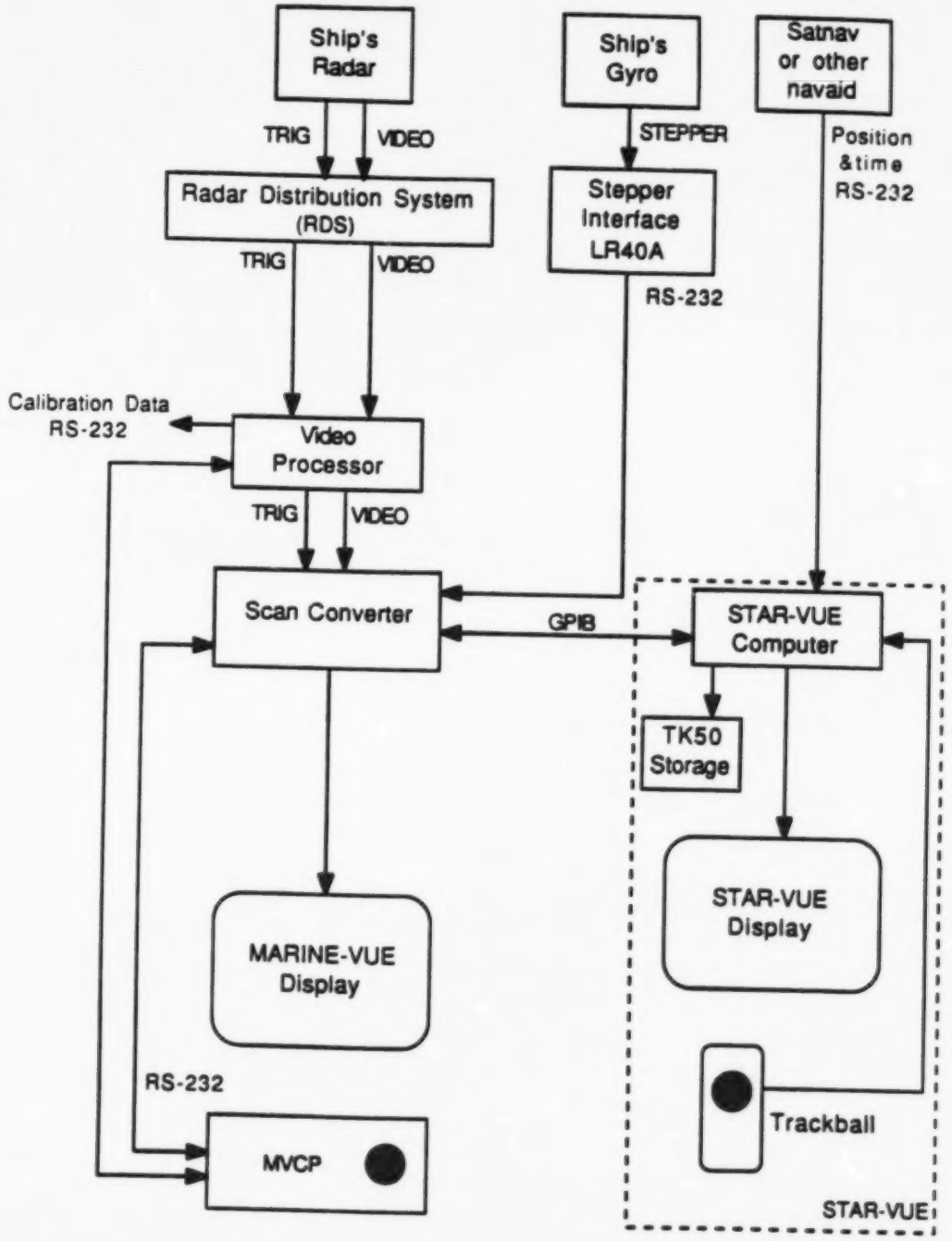


Figure 2. MARINE-VUE Integration without DCVM

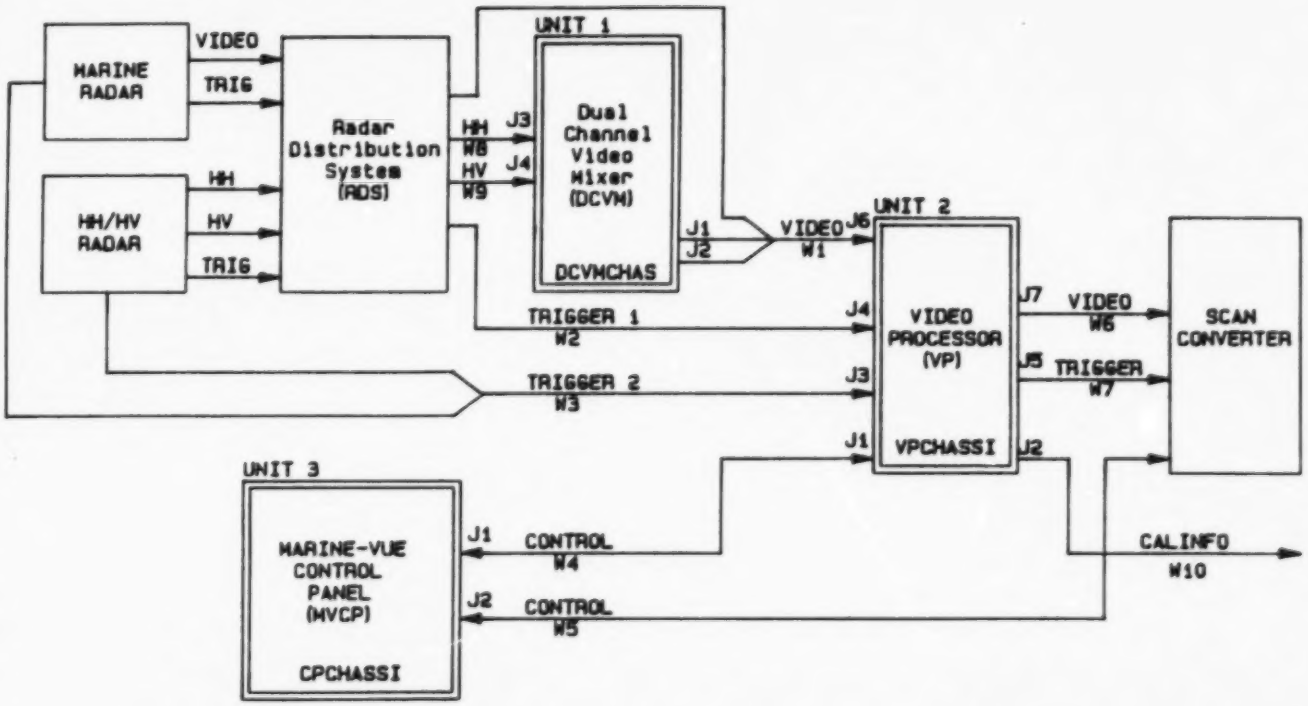


Figure 3. MARINE-VUE Simplified Cabling Diagram

2.0 Specifications

2.1 MARINE-VUE Control Panel

Dimensions:	43.5 cm (W) x 22.5 cm (D) x 9.0 cm (H)
Mass:	4 kg (approximate)
Electrical Connections:	(a) 115 VAC 50/60 Hz, 3A (North American Standard 3-prong) (b) 2 - DB9P connectors for serial communication
Environmental:	Temperature: 0 to 50 degrees Celcius Humidity: 0 to 95% (non-condensing)

2.2 Video Processor

Dimensions:	48 cm (W) x 24 cm (D) x 9 cm (H)
Mass:	3 kg (approximate)
Electrical Connections:	(a) 115 VAC 50/60 Hz, 3A (North American Standard 3-prong) (b) 5 - BNC jacks (Video In, Video Out, Trigger In, (Trigger Out, Blanking Trigger In) (c) 2 - DB9P connectors for serial communications
Environmental:	Temperature: 0 to 50 degrees Celcius Humidity: 0 to 95% (non-condensing)

3.0 MARINE-VUE Control Panel Operation

3.1 Introduction

The MARINE-VUE Control Panel (MVCP) enables the system operator to remotely control the Video Processor (VP) and Scan Converter (SC). Figure 4 shows the front panel layout of the MVCP. Changing switch and dial settings causes the MVCP to send parameter change commands to the VP or SC over serial communication lines. This section describes the operation of the MVCP for controlling the following VP and SC functions:

(a) Offset
(b) Gain
(c) Sensitivity Time Control (STC) Threshold
(d) Sensitivity Time Control (STC) Time Constant
(e) Fast Time Constant (FTC)
(f) Display Mode
(g) Image Rotation
(h) Range
(i) Overlay
(j) PPI Origin
(k) PPI Reset
(l) Cursor Control

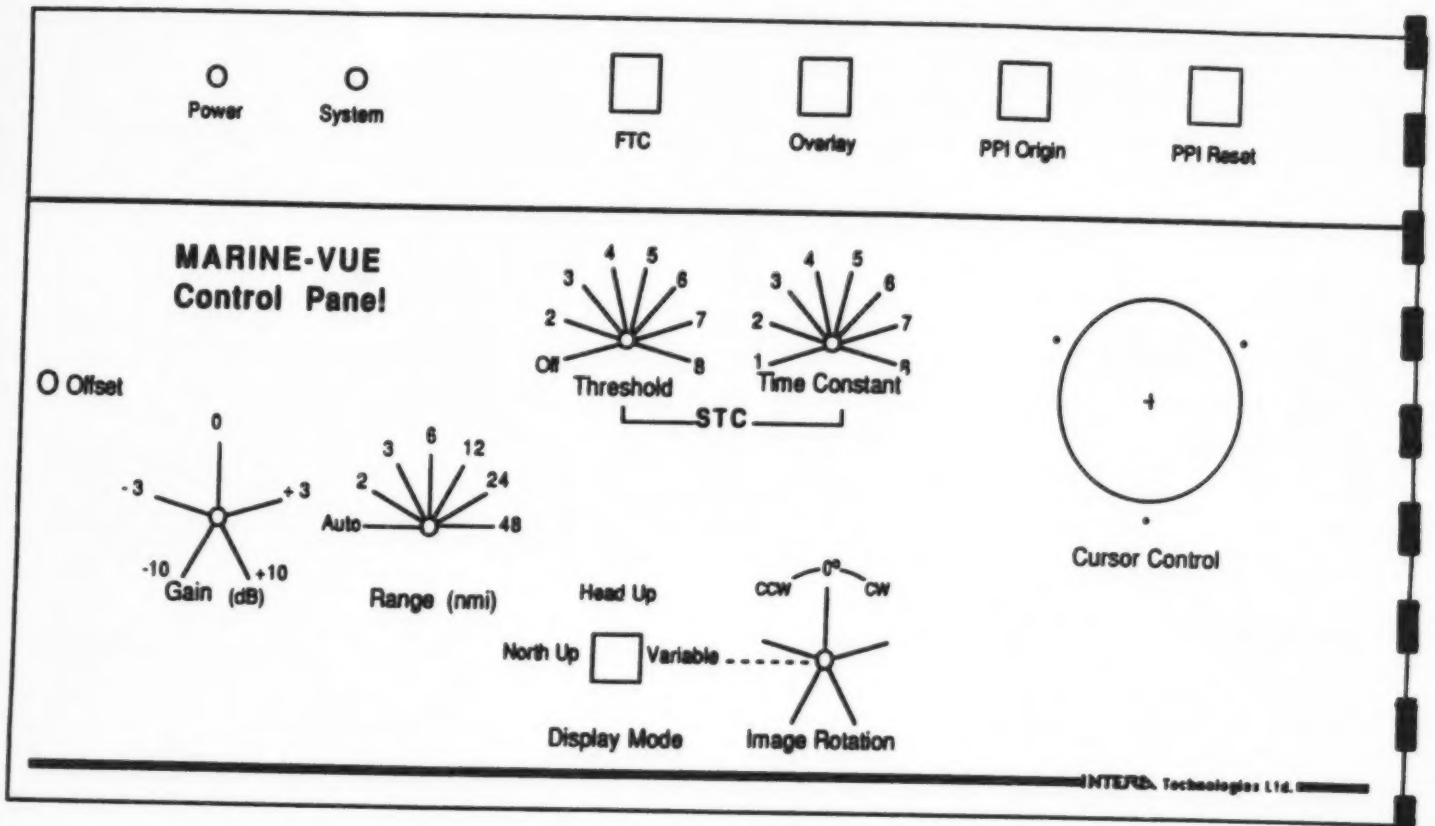


Figure 4. MVCP Front Panel Layout

3.2 Video Processor Functions:

(a) Offset

Calibrates the radar signal's baseline with the VP's reference so that the processed radar signal's baseline is not affected by Gain adjustments. When the potentiometer is set to the middle of its range, the signal is unaffected. Turning the potentiometer counter-clockwise lowers the video signal's baseline, and clockwise rotation raises the baseline. Adjustment of this control causes discrete offset changes due to digitization in the MVCP.

(b) Gain

Increases or decreases the intensity of the received radar signal to adjust the contrast of the radar image. When the knob is set to the middle of its range, the signal is unaltered. Turning the knob counter-clockwise decreases the video signal's intensity, and clockwise rotation increases the intensity. Adjustment of this control causes discrete gain changes due to digitization in the MVCP.

(c) STC Threshold

Selects one of eight STC curves to provide equalization of the radar signal (nearby returns are attenuated to give the radar signal uniform 'brightness' over the entire range). The 'OFF' position disables this function. The remaining STC Threshold positions select equalization curves with various offsets and curvatures (See section 4 for STC implementation details.).

(d) STC Time Constant

Selects the range endpoint for the STC equalization curves. This endpoint determines the range value at which signal equalization ends for the radar scan. Starting at STC Time Constant position 1 and moving to position 8 extends the equalization region outward in range.

(e) FTC

Enables a filter for removing rain and snow returns.

3.3 Scan Converter Functions:

(f) Display Mode

Selects orientation of the radar image. **Variable** mode orients the marine radar image to correspond to the STAR-VUE display. **Head-Up** mode orients the image to correspond to the ship's heading, while **North-Up** mode displays the radar image with the north direction at the top.

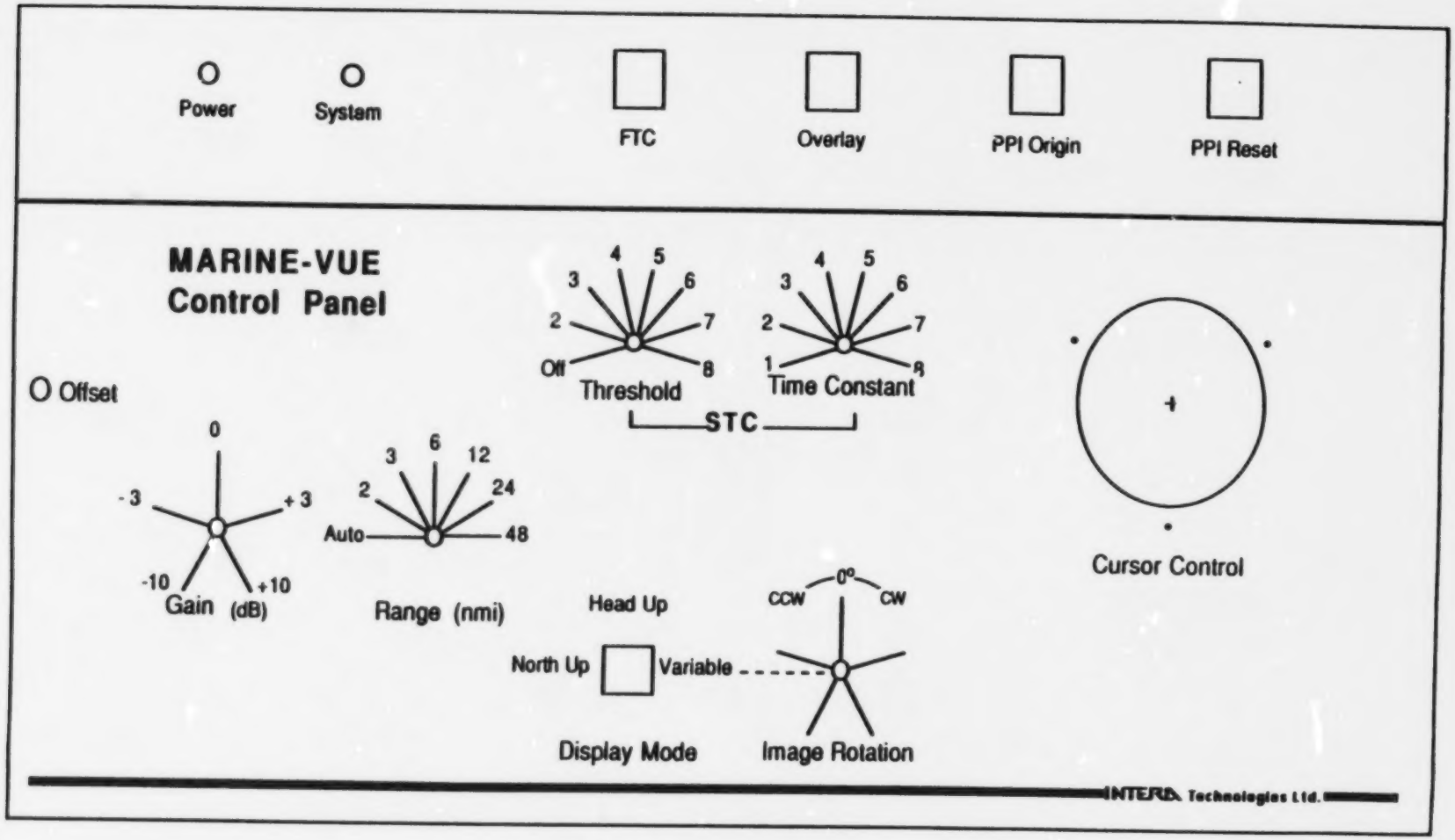


Figure 4. MVCP Front Panel Layout

4.0 Video Processor Operation

The Video Processor (VP) alters radar video signals according to commands received from the MVCP and supplies serial calibration information for a terminal or other auxiliary device. This section describes the basic VP functions and the adjustments available to the operator.

4.1 VP Functions

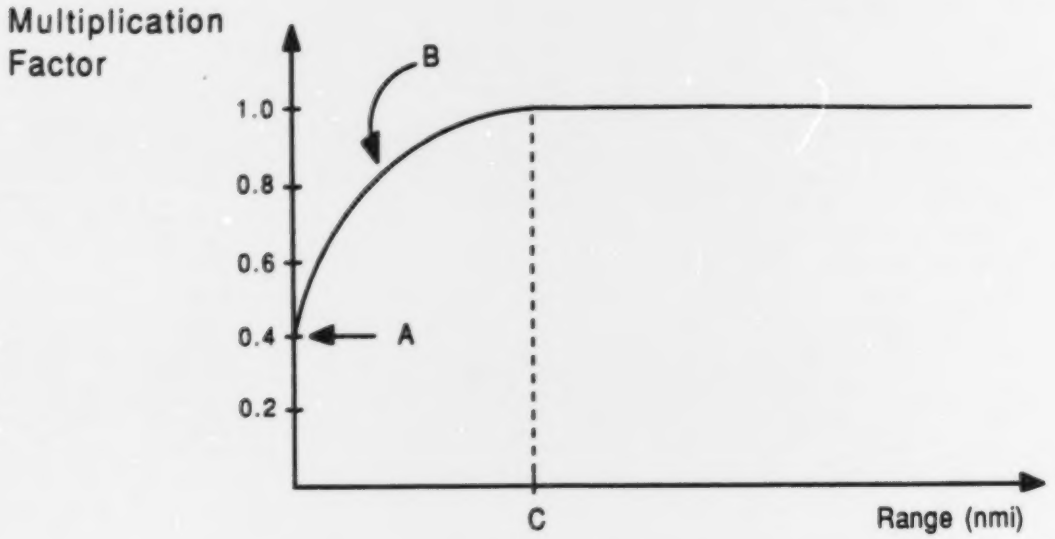
This section outlines the VP functions and their specifications. This information is summarized in Table 1.

Name	Function Performed	min	max
Video Offset *	adds a DC offset to the radar signal	-1 VDC	+ 1 VDC
Video Gain *	applies gain to the radar signal	-10 dB	+10 dB
STC Threshold *	selects STC curve (see section 4.2)	--	--
STC Time Constant *	selects range endpoint for STC equalization curve (see section 4.2).	0.5 nmi	4.0 nmi
FTC *	selects band-reject filter ON or OFF	--	--
Video Blanking	disables video data of one radar while the other is transmitting	1.5 µs	10 µs

* denotes functions which are controlled by the MVCP.

Table 1. Summary of Video Processor Functions

(g) Image Rotation	Rotates the marine radar image only in **Variable** mode. While a full 360 degrees of rotation is allowed, this control is intended for fine tuning of the image's rotation to match the STAR-VUE image.
(h) Range	Selects the range setting for the scan converter display. **Auto** mode allows STAR-VUE to scale the marine radar image to correspond to the STAR-VUE display.
(i) Overlay	Turns on the azimuth ring, range rings, ship's heading mark, and scan converter overlay block to be displayed on the MARINE-VUE display.
(j) PPI Origin	Causes the marine radar image to be redrawn using the present cursor position as the center of the new image.
(k) PPI Reset	Causes the marine radar image to be redrawn using the ship's location as the center of the image.
(l) Cursor Control	Moves the scan converter's cursor.



STC Multiplication Curve

Parameter	Description
A	initial multiplication factor corresponding to range = 0 nmi.
B	STC curvature which is proportional to Range as specified in Table 2.
C	Range value at which the multiplication factor reaches 1.0.

Figure 5. Generalized Multiply Mode STC Curve

4.2 STC Curve Specification

STC equalization is achieved by multiplying the radar signal with an STC curve or subtracting an STC curve from the radar signal. Multiplication mode is used for linear radar signals while subtraction mode is used for logarithmic signals. The STC mode is selected with an internal switch on the VP circuit board. The following sections describe the curves for both modes of operation. Detailed descriptions are contained in the Technical Reference Manual.

4.2.1 Multiply Mode STC Curves

Figure 5 shows a general curve for the STC multiply mode of operation. Eight combinations of initial offset and curvature (parameters A and B, respectively, in Figure 5) are selectable using the MVCP's STC Threshold control. Table 1 contains specifications for these parameters for each MVCP setting. The STC curve's endpoint (parameter C in Figure 5) is selectable using the MVCP's STC Time Constant control. Table 3 contains the endpoint specification for each MVCP setting.

4.2.2 Subtract Mode STC Curves

Figure 6 shows a general curve for the STC subtract mode of operation. Eight combinations of initial offset and curvature (parameters D and E, respectively, in Figure 6) are selectable using the MVCP's STC Threshold control. Table 4 contains specifications for these parameters for each MVCP setting. The STC curve's endpoint (parameter F in Figure 6) is selectable using the MVCP's STC Time Constant control. Table 5 contains the endpoint specification for each MVCP setting.

Curve	A	B	
Off	1.0	R^0	(STC off)
1	0.4	R^3	
2	0.5	R^3	
3	0.6	R^3	
4	0.4	$(R^3+R^4)/2$	
5	0.4	R^4	
6	0.5	R^4	
7	0.6	R^4	

Table 2. Multiplication Mode STC Curve Specifications

STC Time Constant	C (nmi)
0	0.5
1	1.0
2	1.5
3	2.0
4	2.5
5	3.0
6	3.5
7	4.0

Table 3. STC Time Constant Specification

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